

# Ion Generators

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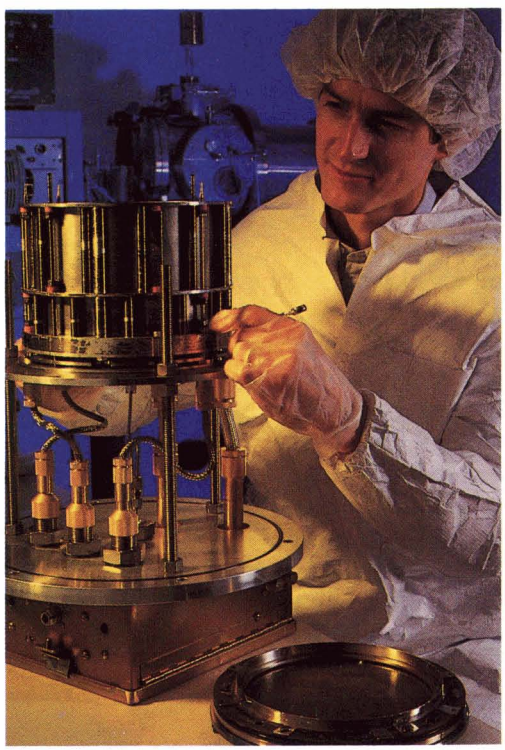
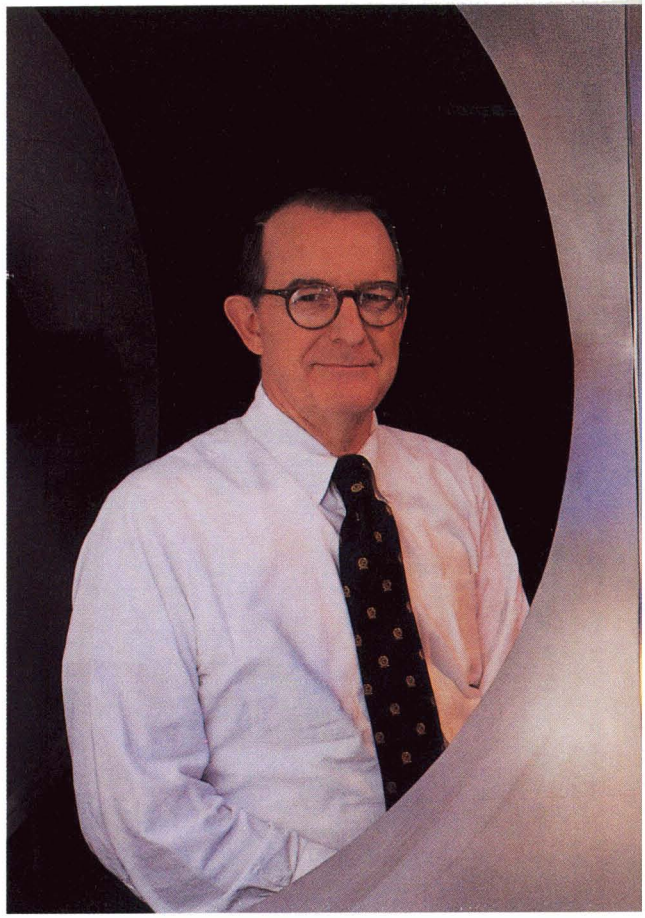
In 1959-60, the first electron bombardment thruster was conceived, developed and tested by Lewis Research Center engineer Dr. Harold R. Kaufman. This and later "Kaufman thrusters" and "Kaufman sources", as they came to be known, were intended for use in a spacecraft electric propulsion technique known as ion propulsion.

Ions are atoms or molecules that have lost one or more of their electrons — and therefore are electrically charged. One method of generating ions for propulsion is by electron bombardment of a gas in a discharge chamber — any gas, but most often mercury or cesium in early work, argon and xenon in most recent applications. The bombardment causes atoms to lose electrons. The ions thus created are accelerated and ejected from the chamber as ion beams. Mixed with an equal number of electrons, the ion beam becomes a thrusting force similar in function to the hot gas exhaust of a chemical rocket, but with a major difference: where the chemical rocket creates high thrust values for short periods, the ion propulsion system generates very low thrust for extremely long periods with very high exhaust velocity.



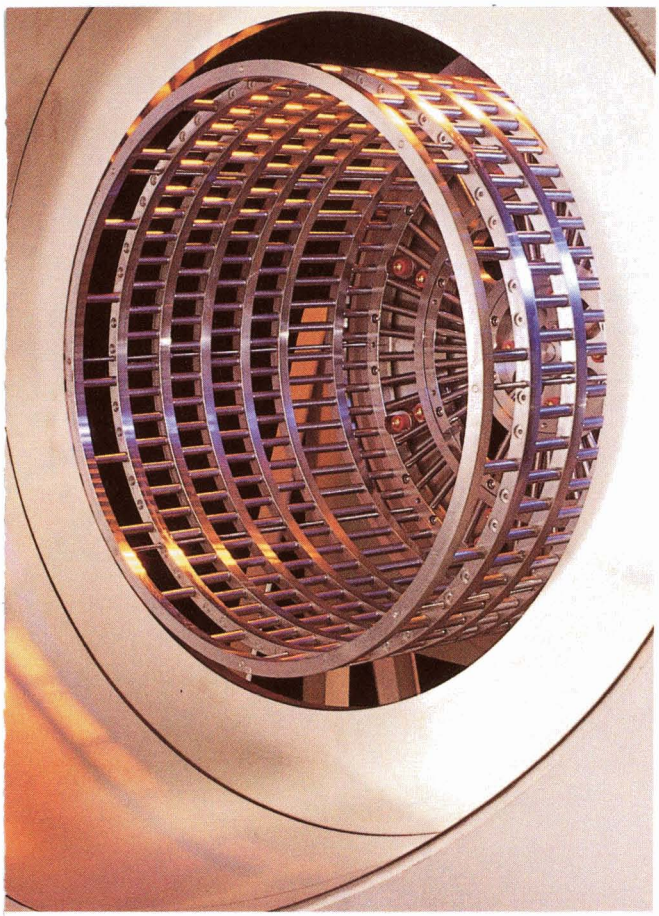
As a primary space propulsion system, an ion engine could theoretically accelerate a spacecraft to a velocity approaching the speed of light for voyages beyond the solar system. It also has utility as an auxiliary propulsion system for spacecraft stationkeeping and attitude control functions.

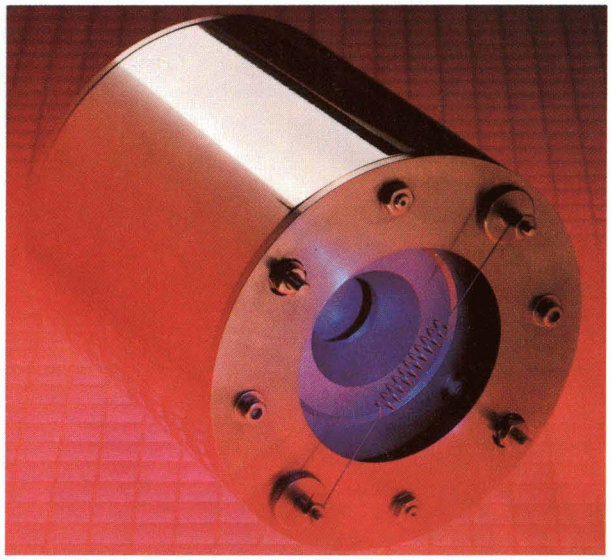


Dr. Kaufman continued his electron bombardment ion thruster work at Lewis until 1974, when he joined Colorado State University as Professor of Physics and Mechanical Engineering. Now with Front Range Research, Fort Collins, Colorado, he is a foremost expert on broad beam ion sources for both space and terrestrial applications.

Dr. Kaufman's ion propulsion devices were used in some space projects, beginning in the mid-1960s, but their potential as a primary propulsion system lies in the future. However, the technology developed for space use resulted in development — starting about 1970 — of a variety of industrial ion beam sources. Several other techniques for ion generation have been developed in the U.S. and abroad, but most broad beam electron bombardment ion sources now in use trace their origins to Dr. Kaufman's work at Lewis Research Center. (Dr. Kaufman developed the 38-centimeter ion source for large capacity, broad beam production applications; in addition to its high processing capability, it offers reliability and ease of maintenance in an industrial environment.)

The principal industrial applications of ion beam technology are in etching microcircuits for electronic systems and deposition of thin films used, for example, as coatings on solar cells or optical





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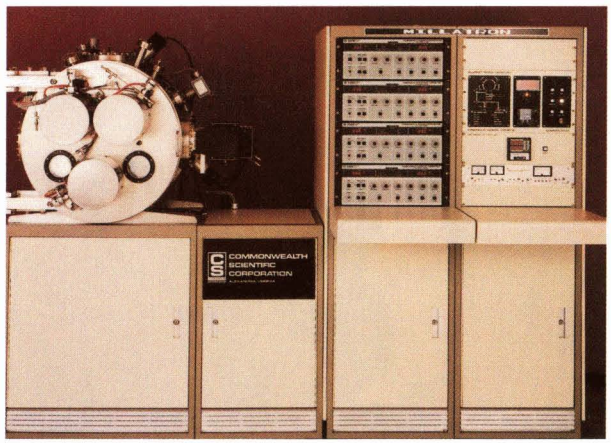


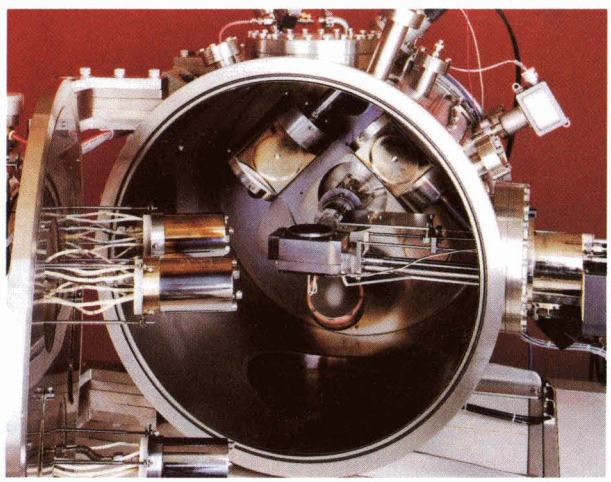

equipment. Recently there has been growing use of ion sources for modifying or controlling the properties of thin films. In a property modification application, the target material is bombarded by an ion beam before, during or after the film deposition process to improve certain properties of the end products, such as adhesion or corrosion resistance.

A company whose product line derives largely from Dr. Kaufman's ion beam technology is Commonwealth Scientific Corporation (CSC), Alexandria, Virginia. Dr. Kaufman serves as a vice president-research and a member of the board; CSC president is George R. Thompson, shown in the **center photo. At far left,** a research engineer is working on assembly of a CSC ion source. **At top right** is a closeup view of a CSC Mark II Gridless Ion Source. The photo **at right** shows a complete CSC etching/deposition system with the ion source chamber at left photo; the chamber is shown in closeup **at bottom right.**

Founded in 1966, Commonwealth Scientific Corporation is a leader in engineering research for the ion beam technology industry and a leading producer of ion beam equipment. The company's product line includes more than a dozen types of ion sources for various applications, power supplies for the sources, surface analysis equipment, thin film coating equipment and a number of related systems.